

CHAPTER 7. ST. LUCIE ESTUARY AND WATERSHED

Introduction

General Overview

The St. Lucie Estuary (SLE) is one of the largest brackish water bodies on the east coast of Florida and a primary tributary to the South Indian River Lagoon. The SLE is located along the Martin/St. Lucie County line on the East Coast of south central Florida. The inner SLE is comprised of the North Fork and South Fork of the St. Lucie River, and has a total surface area of about 6.4 square miles. The two forks converge to form a single middle estuary with a surface area of 4.7 square miles. The middle estuary extends east for approximately 5 miles until it meets the Indian River Lagoon (IRL), just before opening to the Atlantic Ocean at the St. Lucie Inlet (Figure 7-1).



Figure 7-1. St. Lucie Estuary (SLE)

The SLE has been highly altered at both its landward and seaward ends. The system was essentially a freshwater river until 1892 when the St. Lucie Inlet was dug, providing direct ocean access and creating an estuary. The South Fork of the estuary was connected to Lake Okeechobee in 1924 by construction of the C-44. This canal provided a navigable connection to Lake Okeechobee and a route for discharge of excess Lake Okeechobee water to the South Fork of the Estuary. These discharges control high lake levels that jeopardize the integrity of the levee surrounding the Lake. To control water levels in Lake Okeechobee, periodic high-volume freshwater releases have been made to the estuary via C-44 that have varied in duration from days to months and have turned the entire estuary to fresh water.



C-44 Canal in Martin County

During the 1950's, the watershed was enlarged when the North Fork was connected to the C-23/C-24 system that drains much of St. Lucie County. Watershed runoff from the North Fork drainage basins flows quickly into major canals that transverse the coastal ridge (C-23, C-24) instead of being detained, evaporated, cleansed and attenuated by natural systems.



C-23 at S-48

The historic watershed has been extensively modified through regional flood control projects and various secondary drainage systems for agricultural and urban development. Five tributaries to the estuary provide drainage for a watershed that now encompasses 827 square miles. Ten Mile Creek, canal C-24 and canal C-23 empty into the North Fork, while the Old South Fork and the St. Lucie Canal (C-44) discharge into the South Fork. See Figure 7-2.

The SLE can potentially provide vital habitat for substantial populations of fish and invertebrates that have biological and economic importance. However, this ecosystem has been adversely impacted by a variety of watershed and shoreline modifications. Some of major environmental concerns within the SLE include adverse salinity fluctuations, accumulation of sediments and toxins, poor water quality, and loss of seagrass and shellfish resources.



C-24 at S-49

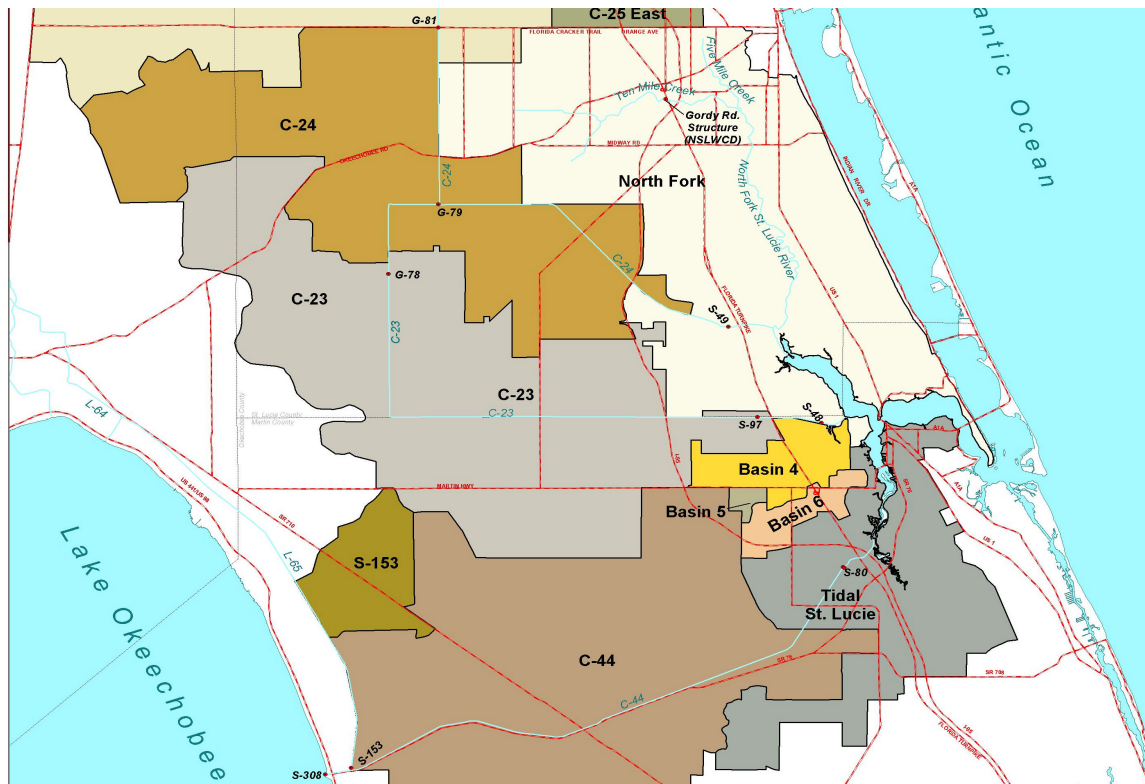


Figure 7-2. SLE Watershed and Basins Map

Excessive freshwater input, sediment loadings, and nutrient loadings associated with urban and agricultural activities can explain the occurrence of these unfavorable circumstances (Janicki *et al.* 1996); (Haunert and Konyha 2001). Runoff from the watershed contains substances from urban and agricultural practices including pesticides and excess suspended solids and nutrients. Therefore, the quality of water entering the estuary through the South Florida Water Management District system is degraded and the quantity, timing, and duration of inflows are substantially altered. However, it is the development of a network of secondary canals that drains urban and agricultural lands within the St. Lucie watershed that is most often responsible for changing the quantity and quality of freshwater flows to the estuary (Chamberlain, 1996).

In addition to the watershed modifications, the estuary shoreline and bottom sediments have been severely impacted. The natural shoreline vegetation once helped stabilize the substrate, filter storm water runoff, and provide quality habitat. Shorelines and inter-tidal areas of the estuary that were once populated by mangroves and other detritus producing vegetation now support very little vegetation. In many areas, seawalls and docks have replaced mangrove and seagrass. (see http://www.evergladesplan.org/pm/studies/irl/irl_impact_statement.shtml)

Estuaries in South Florida suffer from four main problems: (1) disruption of natural freshwater inflows; (2) alteration of natural timing of freshwater flows; (3) increasing input of nutrients and other materials of concern; and (4) loss of critical estuarine habitat and biological communities. (see http://www.sfwmd.gov/org/wrp/wrp_ce/2_wrp_ce_estuary/2_wrp_ce_estuary.html)

Estuaries are the receiving water body for a variety of watershed inputs. Therefore, estuarine restoration and management strategies must be linked to watershed management of surface water, groundwater, and atmospheric inputs in addition to the internal processes occurring in the receiving water body. (see <http://www.sfwmd.gov/org/wrp/>)

Freshwater Inflows and High Discharge Events

Local newspaper reports and anecdotal information from long time area residents, describe the SLE as very productive with good water clarity and a sandy bottom throughout much of its extent in the 1930's and 1940's. For many decades there has been concern in the local community over the deteriorating condition of the SLE and River. Due increased amounts of freshwater entering the SLE, muck ("ooze") has been accumulating faster than historic levels. These unconsolidated sediments are frequently resuspended by wave energy. Resuspension of these sediments releases nutrients to the water column, reduces light penetration, and depletes oxygen in overlying waters. In the winter and spring of 1998 freshwater releases from Lake Okeechobee through the S-80 structure on the St. Lucie Canal (C-44) began in December and steadily increased. Peak flows increased to a maximum of 10,000 cfs between March 1 and April 20, causing drastic decreases in salinity. Due to the combined effects of Lake Okeechobee discharges and local watershed runoff, The SLE, which normally averaged 24 ppt, decreased to 5 ppt during peak flows. Salinities in North Fork St. Lucie River, which normally average 18 ppt, decreased to 0 ppt during peak flows. Within weeks, fish - mostly mullet - appeared with small sores and lesions. The malady spread to more than 25 other species,

Although fish abnormalities have been reported in the SLE system in the past these fish lesions were widely publicized and became a recognized problem, demanding greater scientific study. Several monitoring and research projects were initiated to address this concern. FDEP established a hotline for the public to report diseased fish, and monitoring was initiated to describe the prevalence of fish abnormalities in the SLE and IRL. NOAA later initiated several ongoing projects to analyze fish health problems, characterize fish health and environmental conditions and identify the prevalence and potential causal factors in the St. Lucie system.



St. Lucie Inlet Freshwater Discharges

In April 2000, implementation of the Lake Okeechobee Recession Plan again resulted in billions of gallons of freshwater being released to the St. Lucie Estuary to provide environmental and water quality benefits to Lake Okeechobee. Although these releases may have provided significant benefits to Florida's largest lake, they once again resulted in damage to the St. Lucie Estuary and adjacent waters. The long term solution to these problems -- balancing the need to manage water in the regional water management system with the need to protect the estuary -- lies with developing alternative ways to store and distribute water in South Florida.

Regional Planning Efforts

Lake Okeechobee SWIM Plan

The June 21, 2002 DRAFT of the Lake Okeechobee SWIM Plan provides documentation that describes the operational criteria and major effects of these large discharge events and modifications to the natural system. Combined with other alterations in the watershed, such as increased drainage and changes in stormwater runoff characteristics (Doering, 1995), wet-season flows to the estuary have increased and dry-season inflow characteristics have been altered significantly. These changes have impacted habitats and organisms that depend on brackish or freshwater areas during their life cycle. High volume stormwater discharges produce rapid fluctuations of salinity as well as increased sedimentation. The increase in nutrient and sediment loading has contributed to the build-up of fine-grained, nutrient-rich muck in the estuary. The resultant change in aquatic communities in the estuary consists of more pollutant tolerant benthic organisms and decreases in seagrasses and oysters. All of the impacts described above have adversely affected the 'health' of the St. Lucie Estuary. However, salinity alterations are considered to be the major impact to the St. Lucie Estuary's biological communities. Salinity is considered to be the environmental factor that primarily controls the performance, abundance and distribution of estuarine organisms.

Lake Okeechobee Regulation Schedule

As the local sponsor of the Comprehensive Everglades Restoration Plan (CERP -- <http://www.evergladesplan.org>) and the Lake Okeechobee regulation schedule, the SFWMD must provide a balance between the competing objectives of flood protection, water supply, and protection of the lake's marsh zone and downstream estuaries. To maximize the extent to which this balance is achieved prior to completion of the CERP, a new regulation schedule for the lake was formally adopted by the United States Army Corps of Engineers (USACE) in July 2000. This schedule, the Water Supply and Environment (WSE) schedule uses climate forecasting to determine the volumes of water to release from the lake under flood control circumstances, and has the potential to provide environmental benefits for the lake and downstream systems while not sacrificing water supply. SFWMD and other agency scientists are working with operations specialists to identify environmental "triggers" that can be used in the process of the WSE regulation schedule for determining amounts of water to release from the lake under flood control conditions. The extent of the benefits will depend in part on specific adaptive management protocols that are presently being developed by the District.

IRL Feasibility Study.

The CERP IRL Feasibility Study has created new opportunities for resolving SLE water quality problems, and provides the basis for long term habitat restoration. The feasibility study focuses on large-scale alternative surface water management options in the western portion of the SLE watershed. The objectives of the project are to: improve quality, quantity, timing, and flows to the IRL and the SLE; improve habitat quality of estuarine ecosystems; improve functional quality of watershed wetland ecosystems; reduce sediment loading and flocculent ooze in the estuaries; improve water supply; and provide recreational enhancements. See Chapter 6 for additional details. In conjunction with other CERP projects such as the Ten Mile Creek Water Preserve Area and restoration plans for Lake Okeechobee, it is anticipated that freshwater releases can be greatly reduced and the SLE can be managed to create salinity regimes and habitat conditions that will allow long-term restoration of the estuary.

Estuary Research Plan

The SFWMD estuary research plan identifies future information requirements to support Valued Ecosystem Components (VEC) strategies (USEPA, 1987). Foremost among these are: (1) a need for an enhanced modeling capability in the upper, low salinity zones of the estuary; (2) better biological data for the North Fork of the river and estuary, including seasonal use of the oligohaline zone and salinity needs of benthic, planktonic and nektonic species and communities; and, (3) additional information on oyster habitat sensitivities, reproductive cycles and substrate requirements in the SLE. In particular, technical criteria to support minimum flows in the St. Lucie Estuary (SFWMD, 2002), and the workload required to support the development for the CERP Indian River Lagoon (IRL) Feasibility Study have helped to establish and focus future data collection and modeling needs. Additional information on restoration plans and studies can be found in the Applied Studies section of this chapter.

For more information on SLE history, issues and plans, reference the 1994 Indian River Lagoon SWIM Plan. Other sources are The Citizens' Report to Congress, St. Lucie River Initiative; The Stuart News, November 8 – 11, 1998.

Also: http://www.sfwmd.gov/org/wrp/wrp_ce/2_wrp_ce_estuary/sle.html
<http://www.sfwmd.gov/org/exo/mslsc/index.html>

Oysters, Submerged Aquatic Vegetation (SAV) and Water Quality

Oysters and submerged aquatic vegetation have been selected as the key biological indicators for developing appropriate salinity ranges (and flow ranges) for the St. Lucie Estuary. The oyster species that occurs in the St. Lucie Estuary is the eastern oyster (*Crassostrea virginica*). Three species of SAV have been selected as the most likely to be successful in the St. Lucie Estuary. These species are: shoal grass (*Halodule wrightii*); widgeon grass (*Ruppia maritima*); and wild celery (*Vallisneria americana*).

Establishing Suitable Salinity Conditions

Freshwater Inflow Requirements

Providing a suitable salinity environment is a fundamental prerequisite for establishing a 'healthy' estuarine system. Initial restoration efforts have thus focused on determining what freshwater inflows are needed to provide salinity regimes that will support healthy, sustainable estuarine communities. The conceptual approach for determining minimum and optimal freshwater inflows depends on four supporting components: the Valued Ecosystems Components (VEC) methodology, estimates of the salinity tolerance of estuaries biota, static and dynamic habitat overlap (Browder and Moore, 1981) and hydrodynamic/salinity modeling. (SFWMD, Coastal Ecosystems Division, Draft Research Plan for Estuaries, 2001). The process for determining the magnitude of minimum, maximum, and optimal flows is illustrated in Figure 7-3.

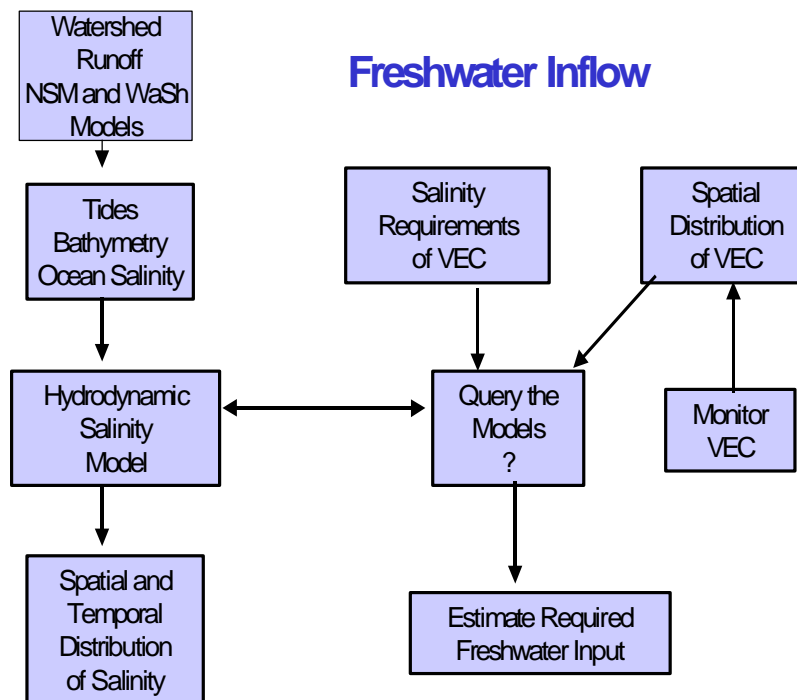


Figure 7-3. Requirements for Freshwater Inflow Management Conceptual Diagram

In addition to establishing limits on the quantity of water entering the estuary, the quality of water must also be considered. Suitable salinity conditions alone will not guarantee a 'healthy' estuarine system. It is also necessary to establish optimum loading ranges for nutrients and other critical

materials. Estuarine water quality can determine the viability of estuarine biological communities (Dennison *et al.* 1993; Stevenson *et al.* 1993). Perhaps the most severe threat to estuarine water quality is eutrophication by nutrient inputs from wastewater treatment facilities, urban and agricultural runoff, and other sources (Gray 1982; 1992; Kennish 1992; Howarth *et al.* 2000). Eutrophication results in altered species composition, reductions in macrophytes and ultimately, anaerobic conditions and mass mortality. Harmful algal blooms, outbreaks of fish lesions, and other undesirable events have been associated with excess nutrient loading (Howarth *et al.* 2000). Salinity and water quality targets are identified based on the VEC requirements. Hydrodynamic and water quality models are used to estimate the freshwater inflows and nutrient loads that produce the appropriate temporal and spatial distribution of salinity and water quality to maintain VEC. Freshwater inflows and nutrient loads are estimated from watershed models.

Salinity Envelope Concept

Using the VEC approach, a favorable range of inflow and salinity was established for juvenile marine fish, shellfish, oysters and SAV. This favorable range is referred to as the “Salinity Envelope.” The “Salinity Envelope” of 350 to 2000 cfs was established for the SLE based on previous research on fish and shellfish, as well as predicted monthly mean salinity from various inflows at designated areas. A family of curves for salinity in the SLE was obtained by providing a salinity model with constant inflows until a steady salinity gradient was obtained (Figure 7-4). Using the family of curves, preferred areas and salinity for oysters and SAV (the salinity envelop) can be seen. This provides a method to predict where ‘healthy’ populations of VEC would exist if the favorable range of flows and salinity were not violated beyond the frequency that is attributed to natural variation of flows from the watershed (Haunert and Konyha, 2001).

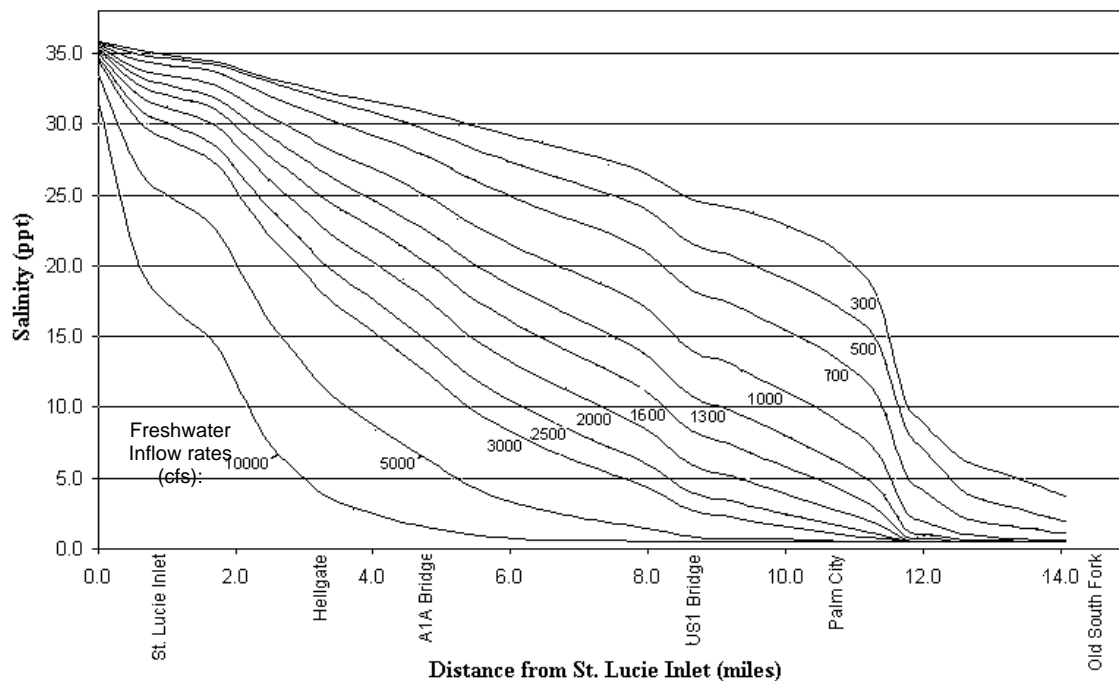


Figure 7-4. Effects of Various Freshwater Inflows on Salinity in the St. Lucie Estuary.

It is the long-term goal of the SFWMD to develop coupled watershed-estuarine models that can be used to: (1) make estimates of historical runoff patterns that preceded human intervention; and (2) evaluate the effects of watershed alterations on receiving waters. Such alterations include changes in canal discharge or point of discharge, operation of storage facilities, impacts of filter

marshes and best management practices (BMPs) on water quality, and operation of coastal structures. These management tools can be used to explore creative ways to meet minimum flows and levels (MFLs) and pollution load reduction goals (PLRGs), to test operational criteria for CERP infrastructure, to define environmentally sensitive operating procedures for existing water management schedules and to establish restoration goals. For additional detail on these four components and other material in support of these strategies for the SLE, refer to: SFWMD, Coastal Ecosystems Division, Draft Estuary Research Plan, 2001.

Oysters

Historic Distribution

Although numerous reports have mentioned oyster presence in the St. Lucie Estuary, very little specific information is available on oyster location, condition, or abundance. Woodward Clyde International-Americas (1998) used information from a literature review and interviews with people who had historical knowledge of the area to develop maps that represent generalized estimates of historical distributions of oysters in the St. Lucie Estuary (Figure 7-5). Oysters were probably never abundant in the lower estuary except along mangrove roots and feeder streams. Significant oyster beds have been reported in the middle estuary from at least the 1940s to present. Small beds have been reported in the South Fork, and scattered beds have been reported in the North Fork since about 1940.

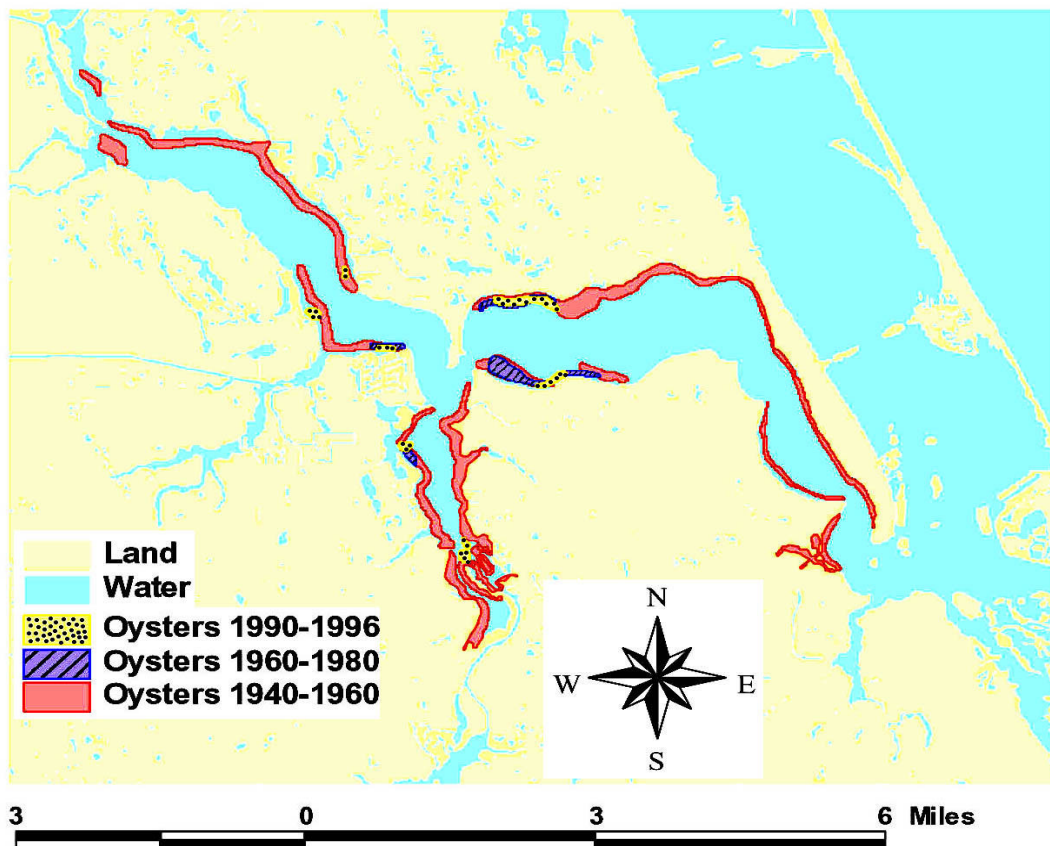


Figure 7-5. Historic Oyster Distribution

Current Distribution

The SLE no longer supports permanent or extensive populations of oysters and seagrasses (Chamberlain and Hayward 1996). Extended periods of salinity below 12 parts per thousand (ppt) can be fatal to oysters, or inhibit feeding, growth and spawning (Chesapeake Bay Program 1991). Increased freshwater inputs and sediment deposition from the SFWMD system, agricultural, and urban drainage canal systems have probably been a major factor in the decline of the oyster in the SLE. In concert with documented declines in seagrass abundance over the last 30 years, oysters have become virtually nonexistent (Janicki et al. 1996). A detailed field survey, GIS mapping of oysters and SAV in the SLE, was conducted in 1997. (URS Greiner Woodward-Clyde, 1999). At that time, 27 oyster beds covering only 208 acres were mapped, but less than 5% of the oysters in 24 of the beds were alive (Figure 7-6).

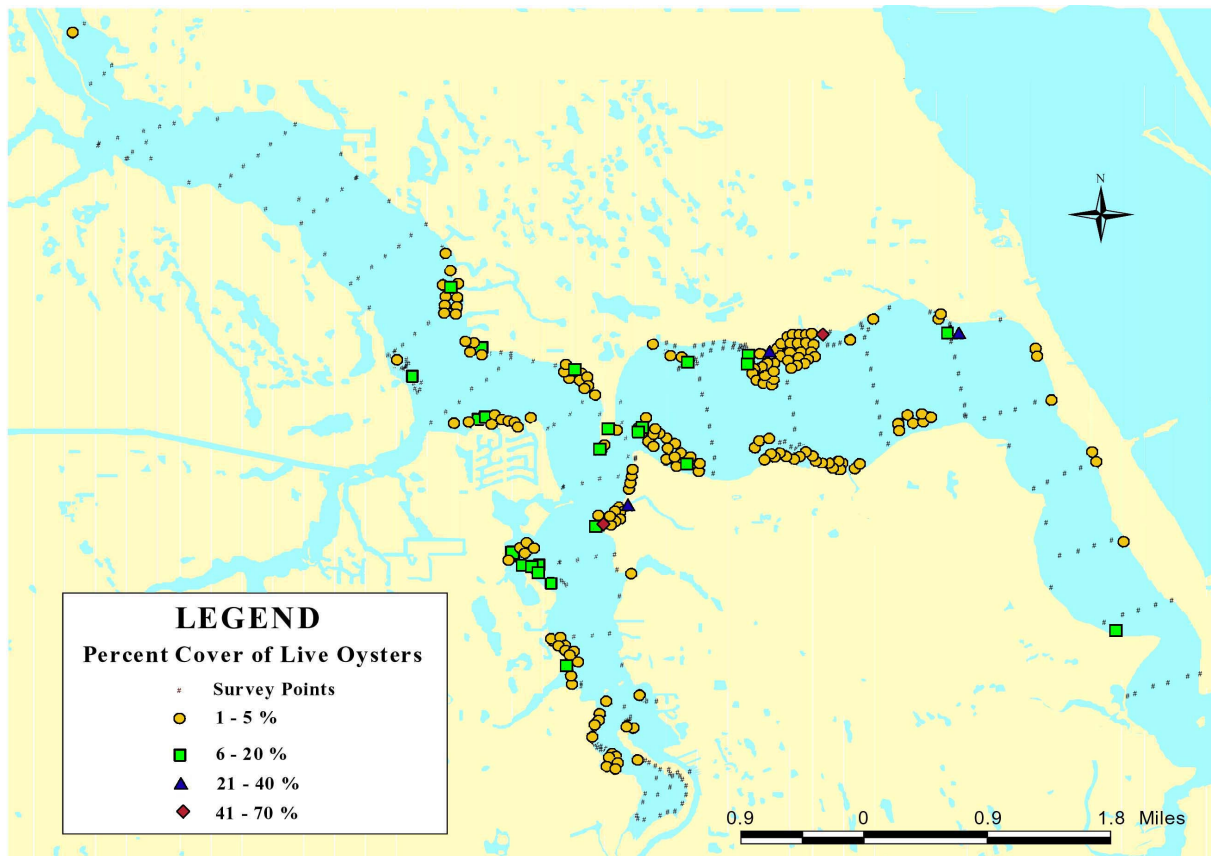


Figure 7-6. Range of the eastern oyster, *Crassostrea virginica*, in the SLE as of 1997.

Resource Assessment

The extent of potentially suitable substrate appears to be significantly greater than the current distribution of oysters in the SLE. The reported historical range of oysters occupies more of the potentially suitable substrate, but again does not include all possible areas. Thus oysters should have the potential to occur in much of the SLE, in a range much larger than they currently exist. For sustained natural production, the key consideration is appropriate substrate for setting of spat.

Substrate “firmness” is recognized as one of the core variables (V6) in the Habitat Suitability Index (HSI) model for the American oyster (Cake, 1983; Soniat and Brody, 1988). Sedimentation and turbidity factors also affect the ability of oysters to colonize different substrates, with the greatest ability to clear sediment from shell margins in coarse sand and the poorest ability in fine sand (Dunnington *et al.*, 1970).

There has been considerable study of alternatives to natural oyster shell as “cultch” (setting substrate) (Butler, 1995; MacKenzie, 1989; Eckmayer, 1983; Chatry *et al.*, 1986; Haven *et al.*, 1987; Thayer *et al.*, 1997). Crushed oyster shell and gravel additives, or mix of these, have been the most common substrates used for both clam and oyster beds. Oyster shell (uncrushed) is superior as cultch, due to the rugosity of the exterior surface of the right valve (Baker and Mann, 1994; Baker, 1997). By developing an irregular surface with gravel or shell on otherwise flat mud flats, settlement of larvae may be increased, and larvae and young spat may have additional protection from predators (Kraeuter and Castagna, 1977).

Based on the overall physiological tolerance range of adult oysters, virtually all of the SLE system appears to have suitable salinity levels. However, numerous other factors are involved in salinity tolerance in natural environments. Based on the 1997 field surveys, there appear to be very limited oyster resources downstream of the middle of the Middle Estuary at Rio. Most of the remaining estuary appears to fall within a salinity range in which at least adult oysters can survive and spawn. Salinity throughout much of the estuary changes rapidly and, in many areas, greatly based on changes in flow and freshwater input.

Oysters are much more susceptible to changes in salinity than to actual salinity levels. The rate of change is also extremely important. Oyster larvae are more susceptible to salinity changes and generally can not acclimate sufficiently to survive. Areas of greatest potential reproductive activity should be defined. Although oysters may reach a sexually mature stage within one growing season, significant reproduction capability requires two to three years to develop. Thus, prime areas would need to be protected from high mortality events for at least this interval to maintain a sustainable population.

Currently, there is little historical data on the reproductive cycle of oysters in the SLE. A recent study has demonstrated peak spawning of oysters in the St. Lucie Estuary begins in early spring (March, April) and a secondary peak in early fall. Understanding spawning periods and distribution of spawning activity within the SLE is regarded as one of the most important aspects of managing oysters for salinity during these critical times.

In summary, a practical lower limit of 7.5–10 ppt may be a suitable SFWMD planning objective in the SLE for most of the year. However, a period of at least a month to six weeks, in most if not all years, may be required during which salinities well above 7.5 ppt (ideally > 10 ppt) are virtually constant. This period should coincide with one of the spawning “peaks”. Realistically, it appears unlikely that restoration or enhancement of sustainable eastern oyster beds in the SLE can be achieved if salinities remain below 10 ppt most of the year.

Submerged Aquatic Vegetation (SAV)

Historic Distribution

There are very few published references to SAV distribution in the St. Lucie Estuary. Woodward Clyde International-Americas (1998) used information gained through a literature review and from interviewing those with historic knowledge of the area to develop historic St. Lucie Estuary SAV maps (Figure 7-7). These maps should not be interpreted as absolute locations or acreages, but as generalized estimates of historic distributions.

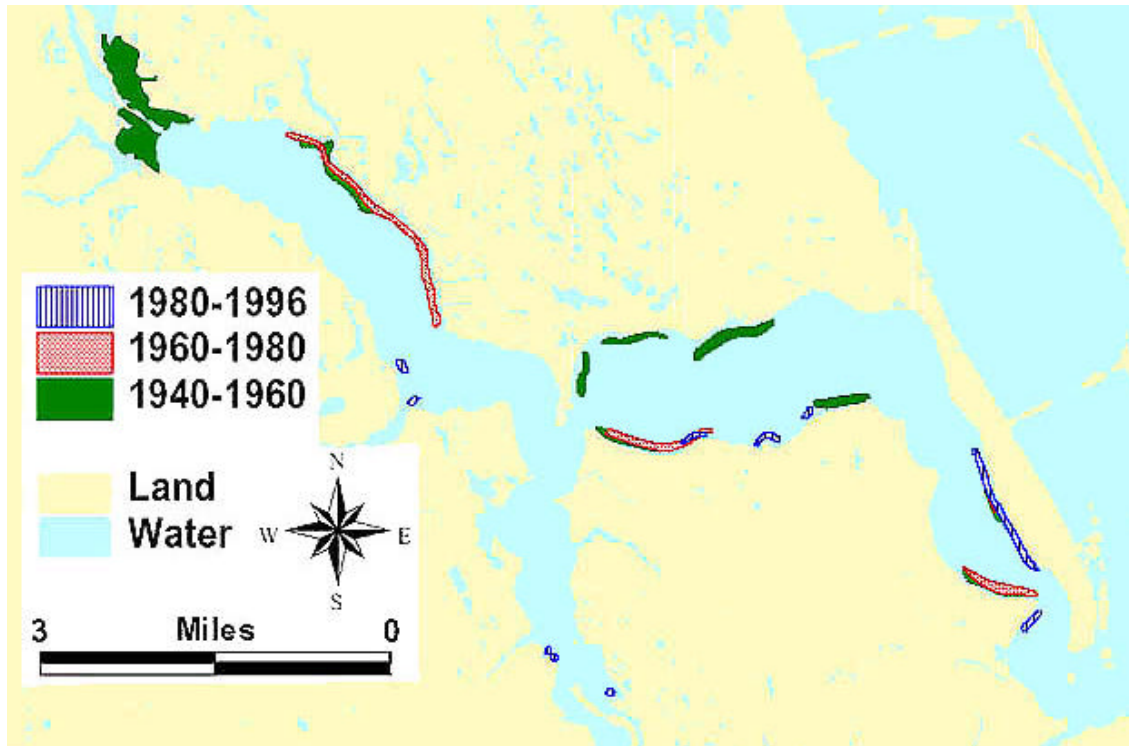


Figure 7-7. Historic Submerged Aquatic Vegetation

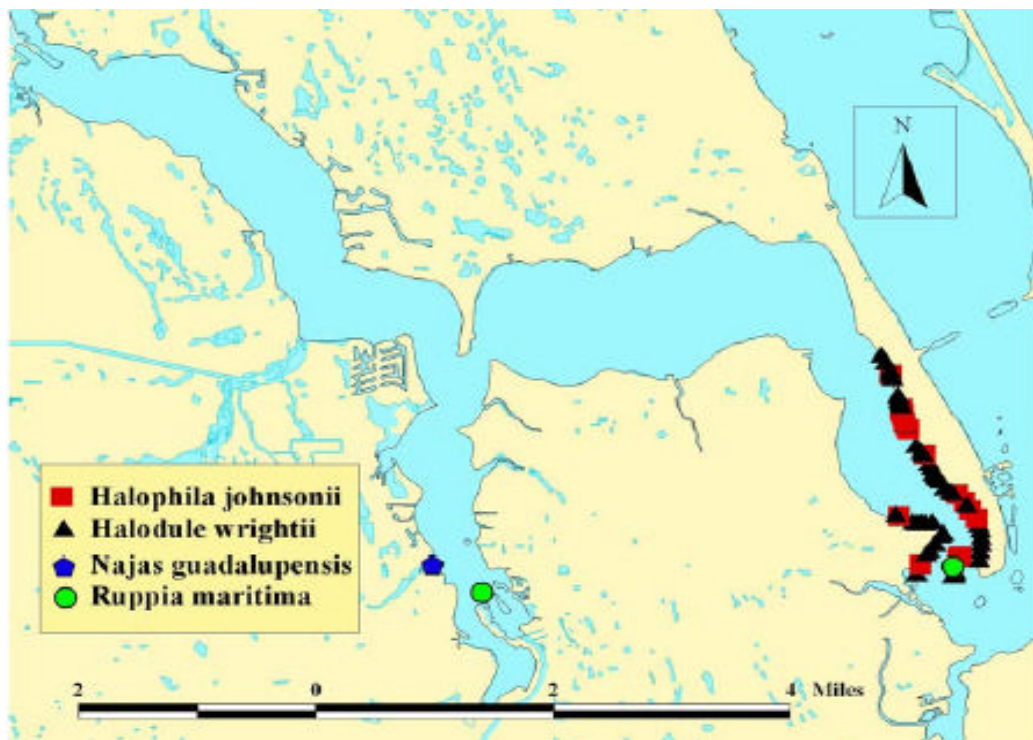


Figure 7-8. Range of submerged aquatic vegetation in the SLE as of 1997